Results of Q-Disease Tests with 350-MHz Spoke Cavities

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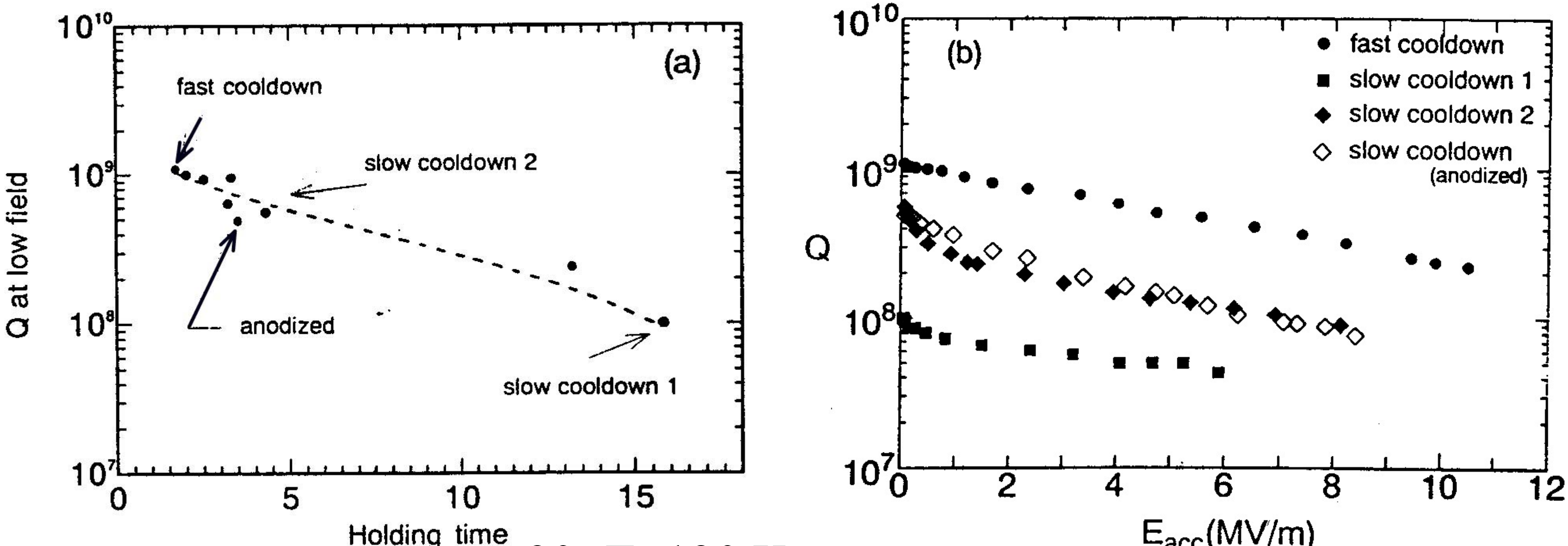
Background

- Elimination of high temperature (>600 °C) hydrogen degassing will lead to a significant cost reduction
- There have not been enough data at low-frequency (<400 MHz) superconducting (SC) cavities to determine the occurrence of Q disease, although it was mentioned that there is less effect on low-frequency cavities (which has not been proved.)

129.8-MHz, SC QWR Results at JAERI (Shibata et al., 1993 SRF Workshop at CEBAF)



90<T<130 K

Electro-Polishing ~120 microns in a closed environment.

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Research Objectives

- Determine if Q disease occurs with 350-MHz spoke cavities, if it does,
- Determine the precise temperature range at which the Q disease occurs
- Determine the dependence on the holding time
- Check on frequency dependence

Methods

1. Get Q-E curves of the 350-MHz cavities that we have. So far, 3 cavities have been tested.
2. To determine the temperature range in which Q disease occurs, change the holding temperature every 10 K between 70 K and 170 K. This is under way.
3. After determining the worst temperature, hold the cavity at this temperature with different holding time. This has not been done yet.
4. Measure the amount of Hydrogen in the material used for the fabrication of the cavity and its increase due to our chemical polishing. This is to be done in the future.

Result with β=0.4, 340-MHz spoke cavity loaned from ANL

The cavity parameter

Effective cavity length	0.298 m
Cell diameter	0.443 m
R/Q	473.4 ohms
Geometrical factor	82 ohms
E_{pk}/E_a	4.0
B_{pk}/E_a	10.7 mT/MV/m

Buffered Chemical Polishing Parameters

Etching rate	~ 0.7 μm/min
Total etched thickness	98 μm
Etching solution bath temperature	6 – 10 °C
Cavity temperature during BCP	14 – 18 °C
Process after etching	Filled with DI water and drained 4 times

RRR~150

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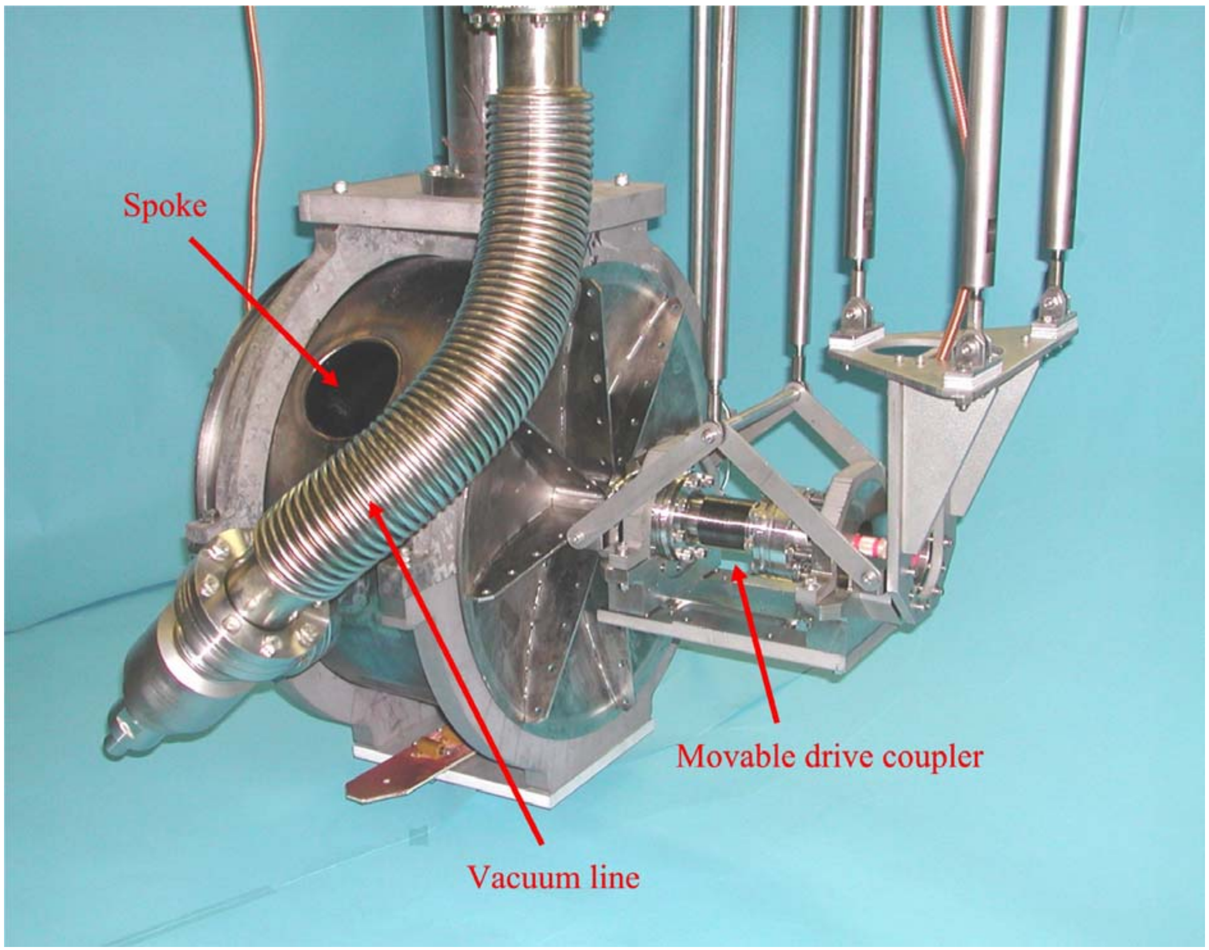
β=0.4, 340-MHz spoke cavity loaned from Argonne National Lab (ANL)



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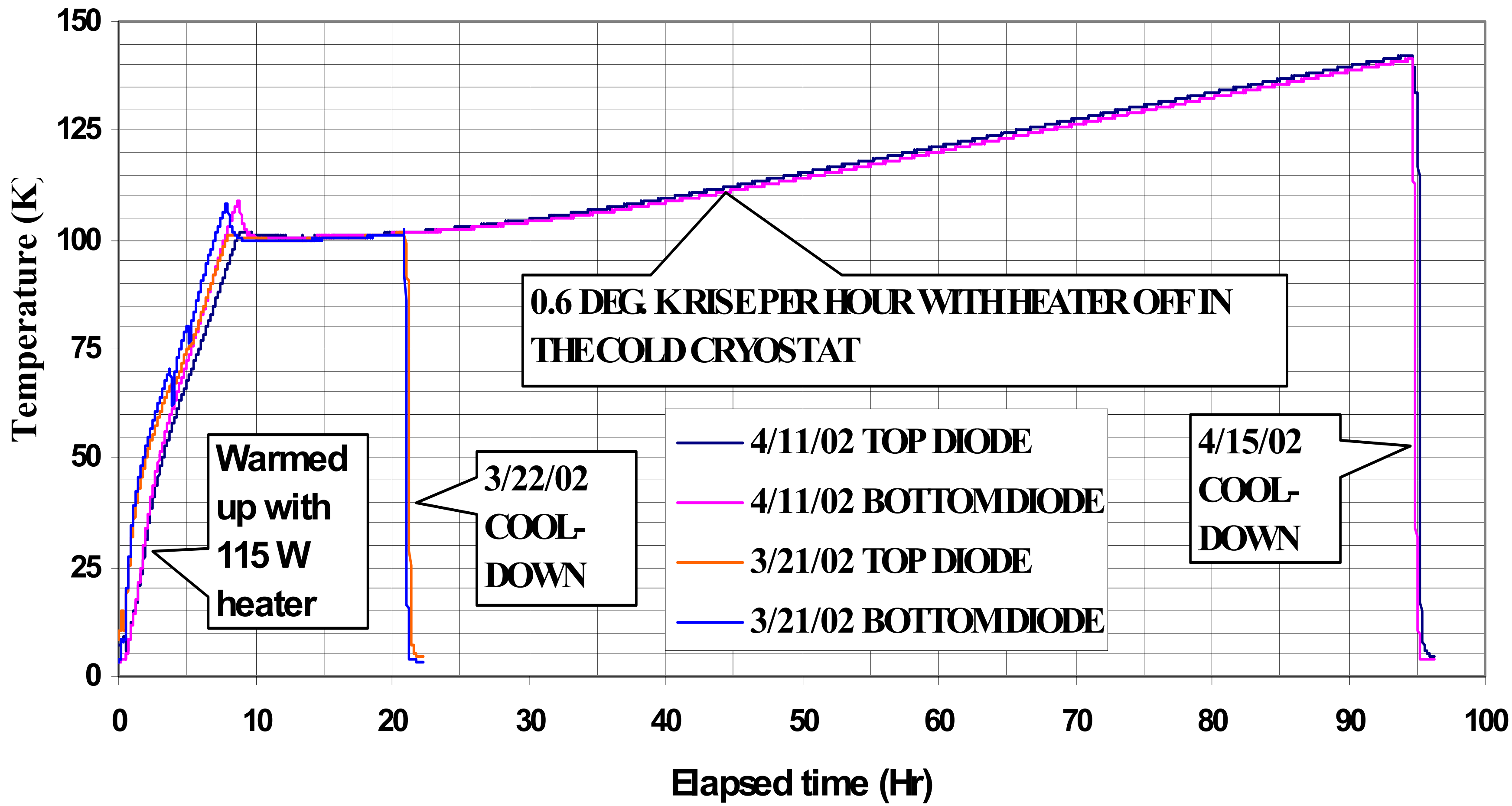
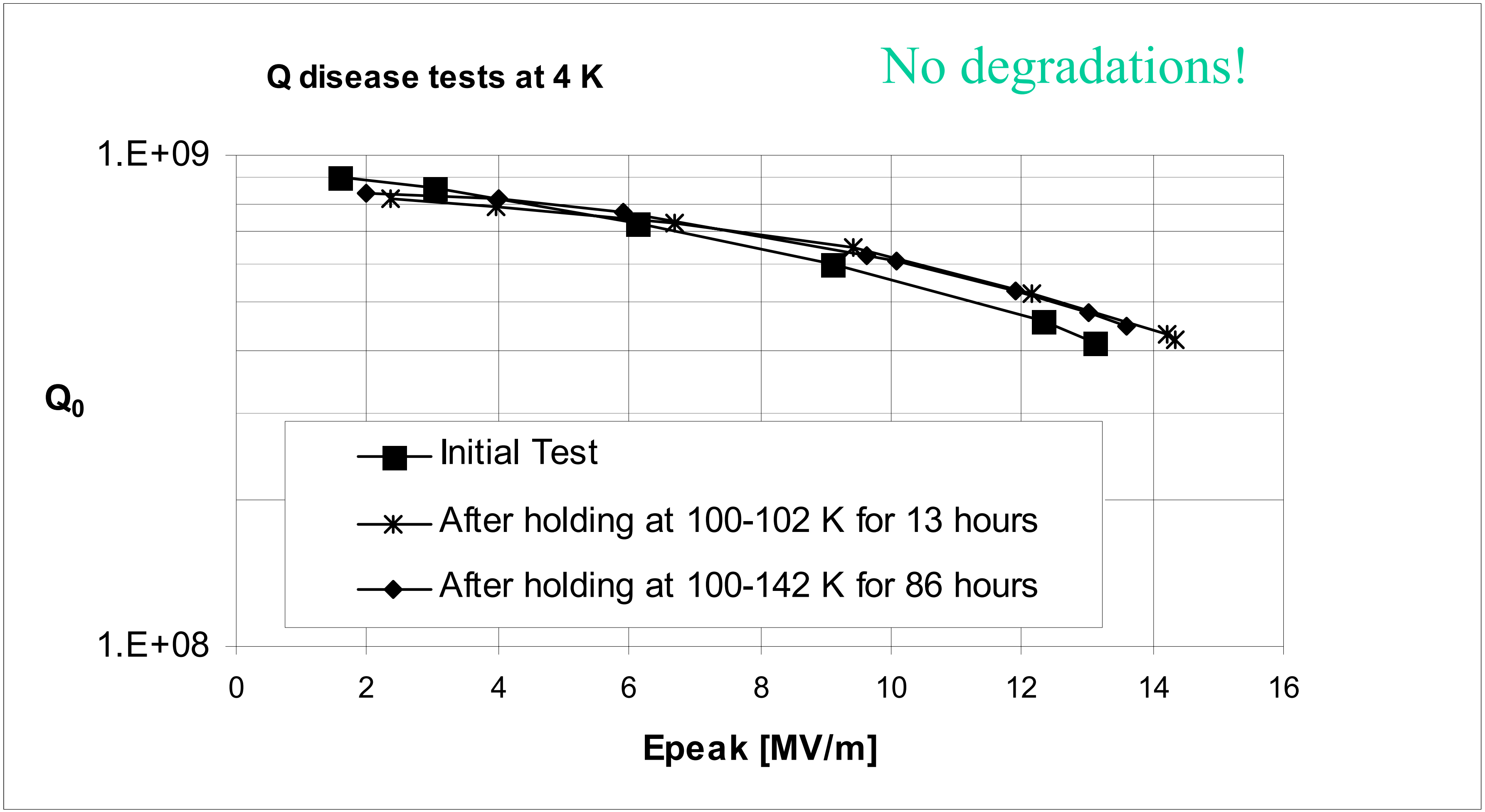
Temperature evolution for the test. Stopped the heater at 100 K.



Q-E curves after holding the cavity at 100 – 142 K



This cavity was unintentionally baked at ~250 °C at ~ E-4Torr.

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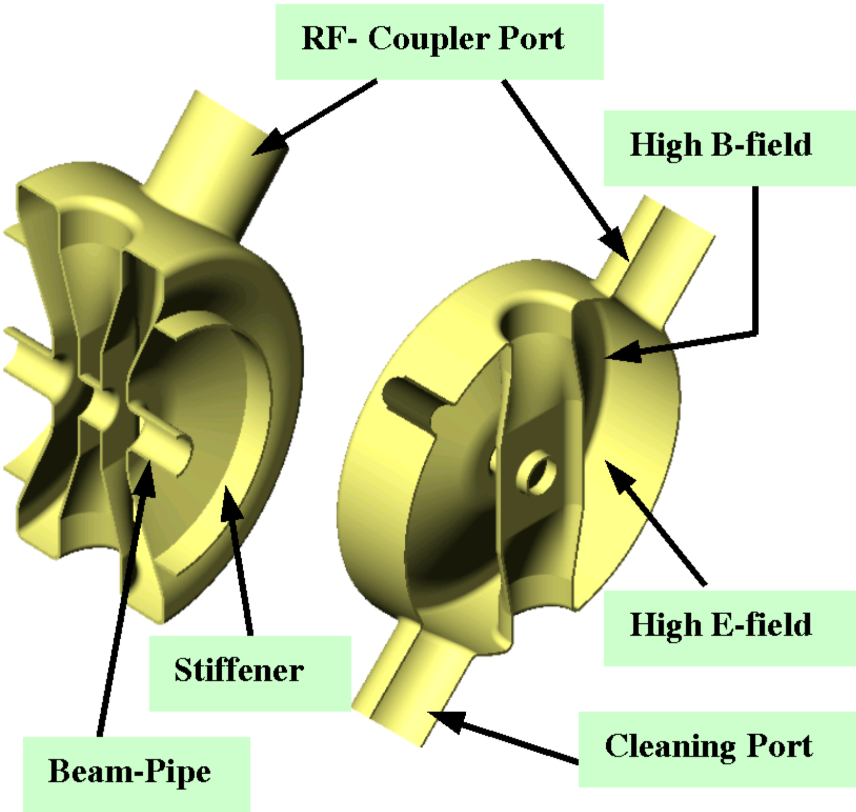
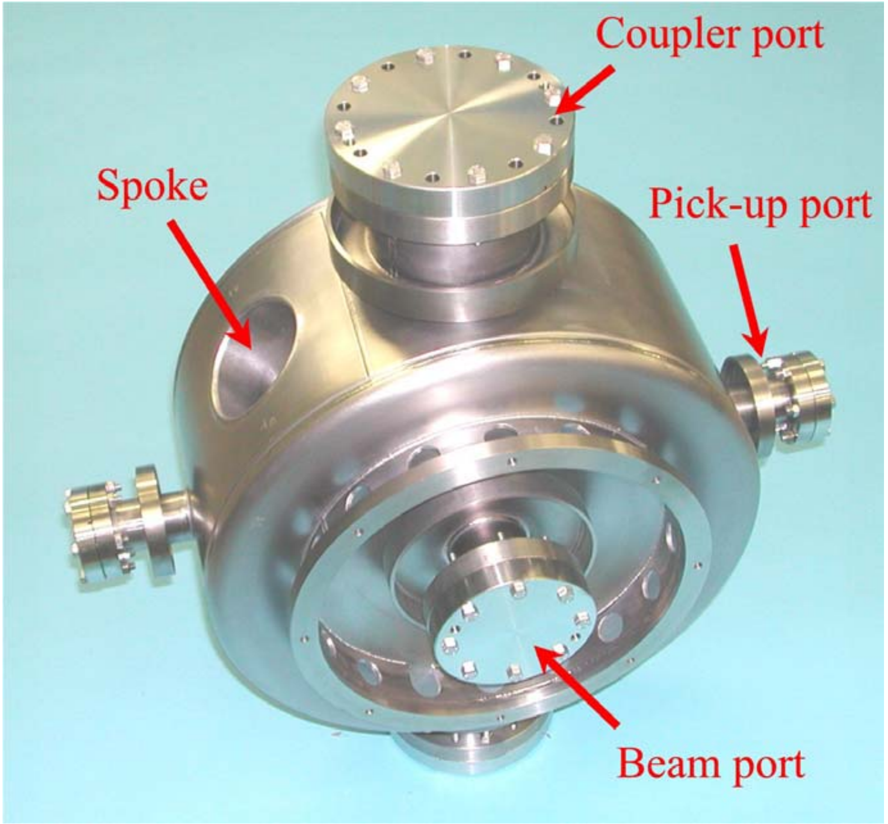
The LANL/AAA β=0.175, 350-MHz Spoke Cavity





Two cavities (EZ01 and EZ02) were procured from Zanon, Italy.

The Cavity Dimensions

Cavity Diameter	39.218 cm
Spoke Diameter at Base	9.0 cm
Spoke Thickness at Aperture	3.5 cm
Spoke Width at Aperture	11.44 cm
Aperture Diameter	5.00 cm
Cavity Length (gap-to-gap)	9.99 cm
Cavity Overall Length	19.99 cm
Cavity Length (flange-to-flange)	28.6 cm
Coupler Port Diameter	10.3 cm
Pick-up Port Diameter	3.81 cm
Initial Nb thickness	3.5 mm

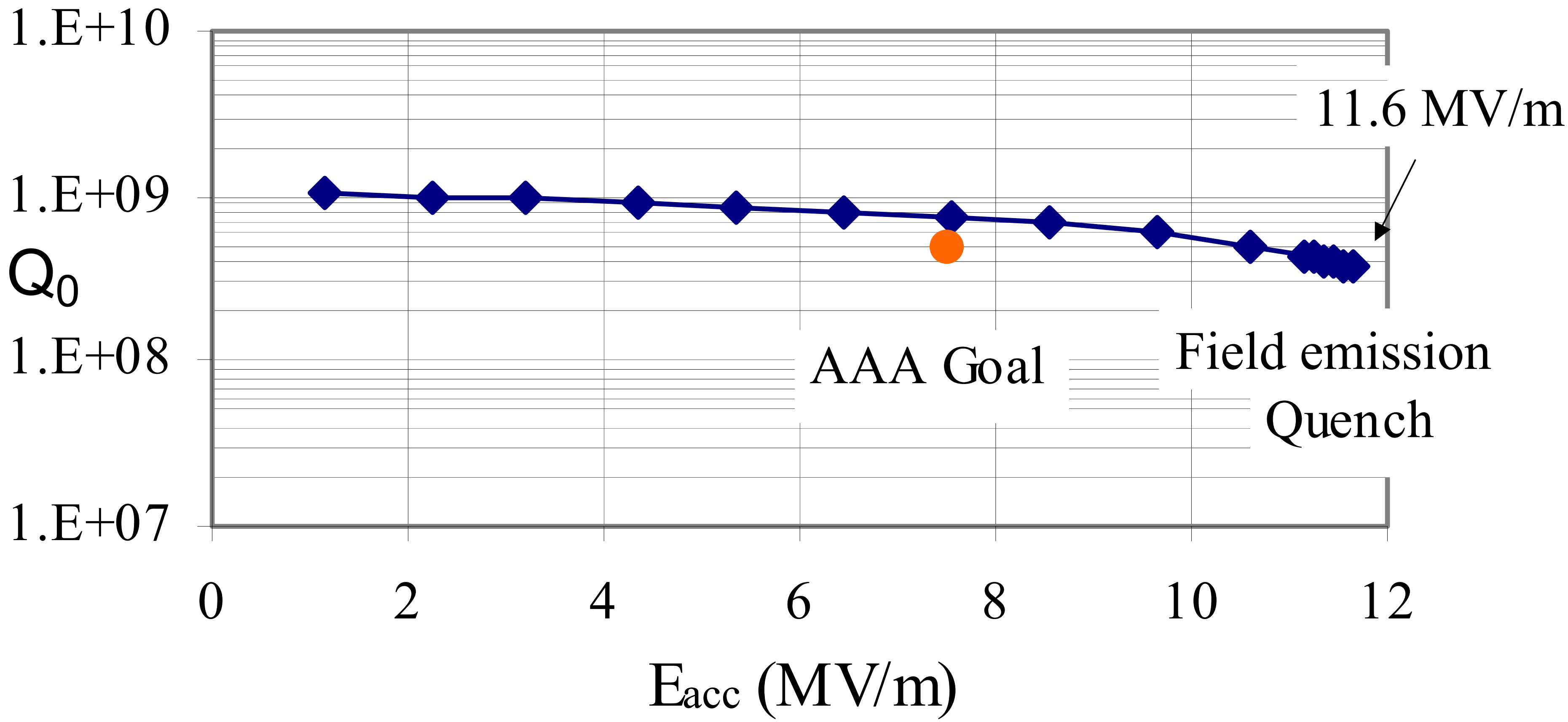
RF Parameters

Q_0 (4 K)	1.05E+09 (for 61 nΩ)
T (β_g)	0.7765 (β_g=0.175)
$T_{max}(\beta)$	0.8063 (@ β=0.21)
G	64.1 Ω
E_{pk}/E_{acc}	2.82
B_{pk}/E_{acc}	73.8 G/MV/m
P_{cav} (4 K)	4.63 W @ 7.5 MV/m
R/Q	124 Ω

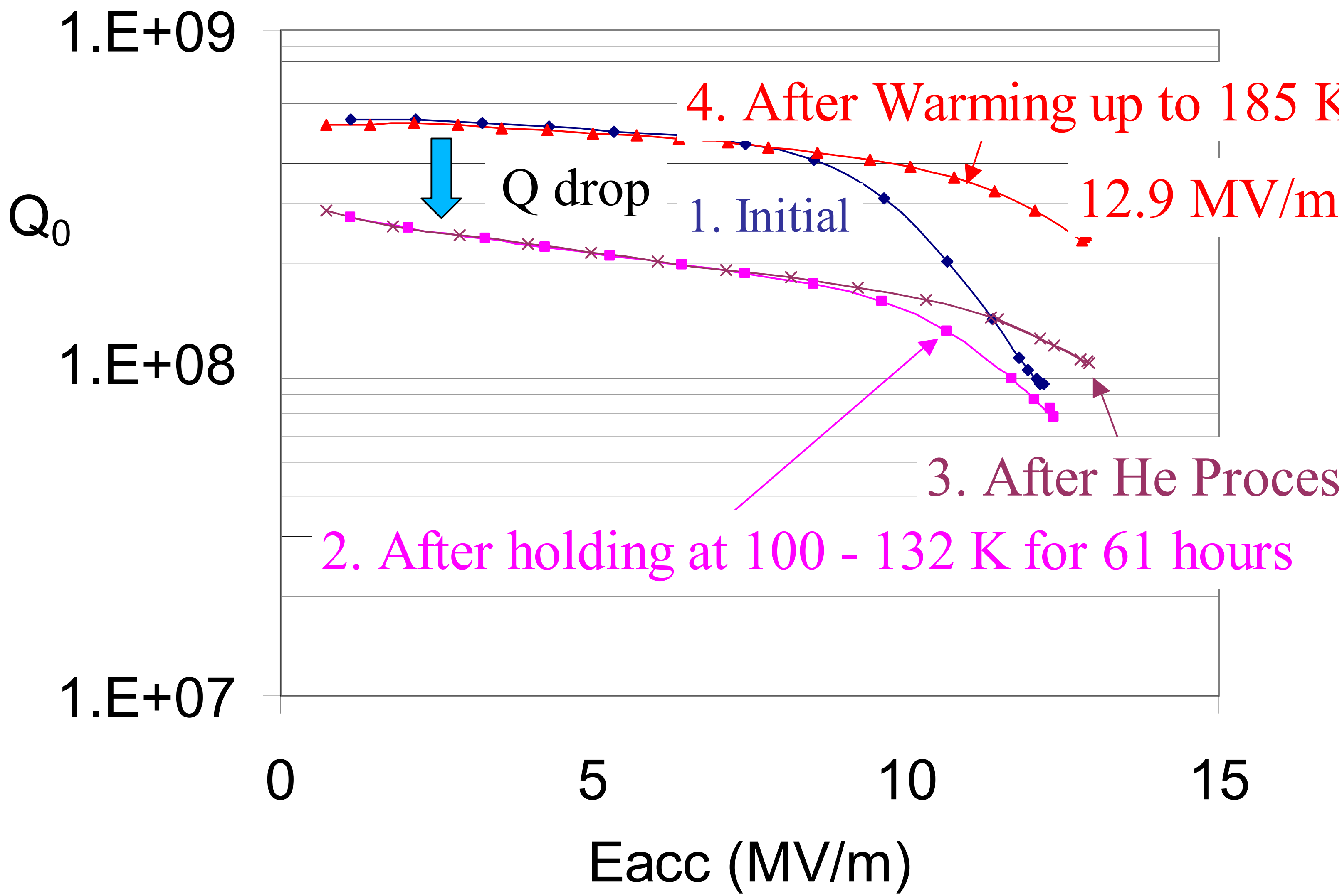
Test Preparation

- Buffered Chemical Polishing (BCP) ~ 150 μm with $HF:HNO_3:H_3PO_4$=1:1:2 by volume.
- High Pressure Rinsing (HPR) at 1000 – 1200 psi (69 – 83 bar) for a total of ~50 min.
- Set up on the cryostat insert, pump down and baking at 100 – 110 ºC for ~ 2 days

EZ02 with Nb flanges on the large radial ports – 4 K test

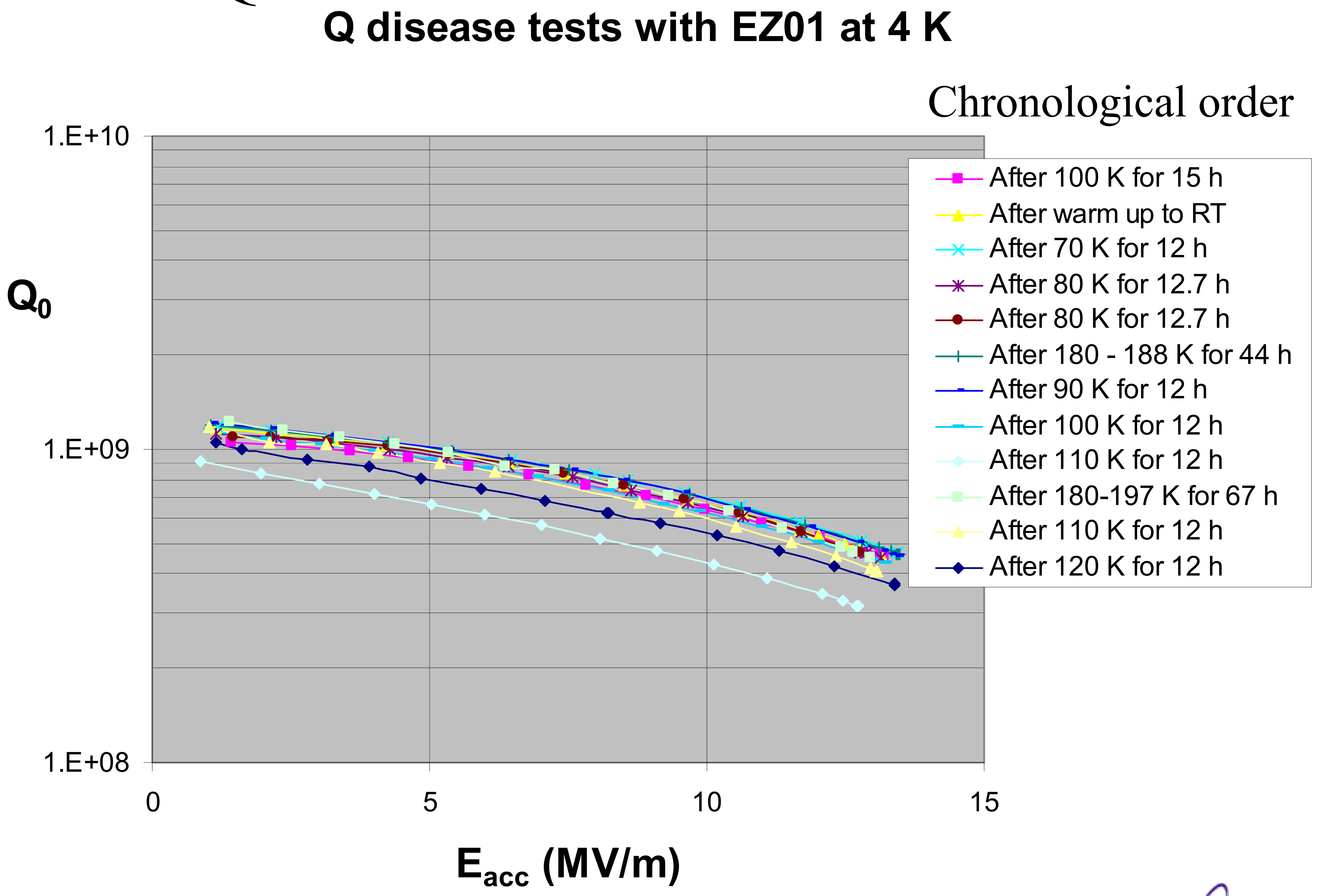


EZ02 Test on Q Disease and He Process



Stainless steel flange on one of the large radial ports.

Q disease tests with EZ01



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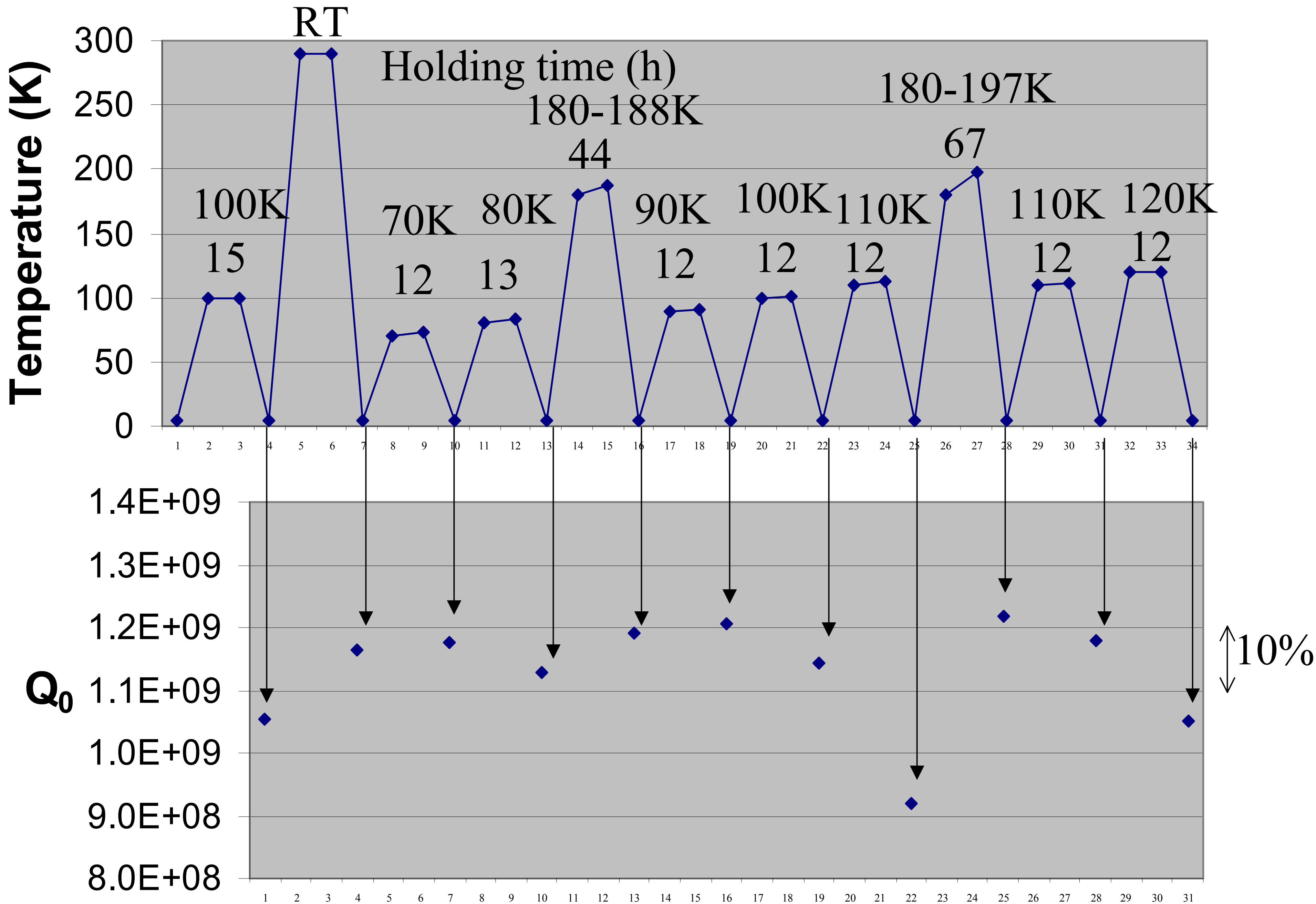
History of the temperature change and corresponding Q_0



Note that Q_0 is in linear scale.

Interim summary of the results with EZ01 cavity

- The occurrence of Q disease has been checked starting at 70 K at every 10 K for ~ 12-15 h.
- Q degraded by ~15 % by holding the cavity at 100 K for 15 hours.
- Q does not seem to degrade up to 90 K by holding the cavity for 12 h, but precipitation seems to have started even at lower temperatures.
- Q disease disappears if held at 180 K. From what temperature this effect occurs needs to be determined.

Summary

- Q disease on 350-MHz Nb spoke cavities has been investigated.
- One cavity (RRR~150) with 98-micron BCP and excessive baking (~250 °C at ~E-4 Torr) showed no degradation. Effect of oxydized layer?
- Two cavities (RRR~250) with 150-micron BCP showed small degradation.
- A systematic test on the temperature range and time dependence is under way.

Future plan

- Determine the precise temperature range of Q disease occurrence
- Determine the time dependence
- Measure the content and depth profile of H in the material
- Determine the effect of BCP process on the Hydrogen content in the material
- Collect more data on frequency dependence